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HUNTERIAN LIGATION OF ARTERIES

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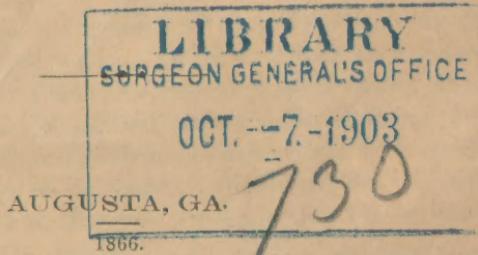
RELIEVE AND TO PREVENT DESTRUCTIVE INFLAMMATION:

BY

HENRY F. CAMPBELL, M. D.,

PROFESSOR OF ANATOMY IN THE NEW ORLEANS SCHOOL OF MEDICINE; AND,  
DURING THE WAR, CONSULTING SURGEON TO THE GEORGIA  
HOSPITALS IN RICHMOND, VA.

[Extract from the August (1866) No. of Southern Journal of the Medical Sciences.]





George A. Otis M.D. U.S.A.

With Compliments of  
His Friend THE AUTHOR.

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By HENRY F. CAMPBELL, M. D.,

PROFESSOR OF ANATOMY IN THE NEW ORLEANS SCHOOL OF MEDICINE,

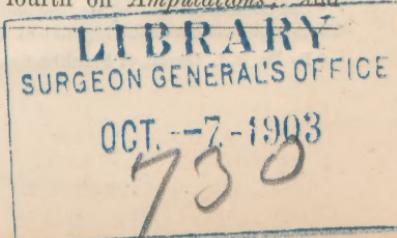
And, during the War, Consulting Surgeon to the Georgia Hospitals, Richmond, Va.

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A NUMBER of communications have recently appeared in the Medical Journals of the country, the object of which was to discuss the value of the above procedure as a means of preventing inflammation. All these articles refer—generally, with great fairness—to a paper of our own, published during the late war. As this paper was, at the time,\* put forth *anonymously*, and still more for the reason that the subject was therein but imperfectly considered, we feel it our duty, in declaring formally our authorship of the publication, to present a more detailed account of the cases, together with more extended considerations relating to this important measure of practice.

During the war, just ended, the difficulties of communication attending the blockade rendered it impossible to supply the army with convenient and suitable medical works. Dr. S. P. Moore, then Surgeon-General of the Confederate States, determined to issue a work on Operative Surgery, for the use of medical officers in the field and in the hospitals. The necessarily compendious character of the work restricted its teachings to only a few of the more prominent subjects of military surgery:—A brief chapter on *Surgical Diseases*; another on *Gunshot Wounds*; a third on *The Arteries*; a fourth on *Amputations*; and

\* Richmond, October, 1863.



one on *Resections*, exhausted the entire scope of this little volume. We do not feel at full liberty, without their consent, to divulge the names of the distinguished gentlemen who were our colleagues in the assigned duty of the preparation of this manual for the army. Our own name has been mentioned in connection with the third chapter, on Traumatic Hæmorrhage and the Arteries, by our friend Prof. Daniel F. Wright, formerly of Nashville.\* His deep interest in the subject of the present paper—Ligation of Arteries for the cure of Inflammation—therein incidentally discussed, has been, we confess, most gratifying to us, as eminently calculated to direct the attention of the profession to the subject, and to elicit discussion on a mode of practice which we can but regard as one of the greatest value, under certain circumstances, in the treatment of inflammation.

The method of ligation proposed, or rather *revived* by Mr. Guthrie, is advocated throughout our chapter for nearly all cases of traumatic hæmorrhage, whether primary or secondary, while that of Hunter is strongly objected to. Certain exceptional cases, however, are discussed, wherein it is taught that Guthrie's double ligature at the seat of injury may be advantageously replaced by the method of Anel and Hunter, in which a single ligature is applied at some distance above the arterial lesion. The most prominent among the exceptional conditions is the one,—everywhere dwelt upon—wherein the condition of the wound, and of the limb, was such as to indicate a liability to extensive or even destructive inflammation. In such cases, our experience and observation, very early in the war, had taught us that the risk of hæmorrhage by the recurrent circulation was not to be weighed against the great advantage of curing, or at least controlling, the inflammation—indeed, saving the limb and the life—by the ligation of the main arterial trunk which supported this inflammation. A recent number of the Cincinnati Journal of Medicine† presents a *verbatim* abstract of our views as found in the chapter before referred to, and, indeed, except for the advantage of presenting a fuller account of these principles in connection with a more extended report of the cases from our private notes, it would be scarcely necessary to reproduce any portion of that chapter in the present paper.

We here present a somewhat fuller abstract, and our further comments upon the method of treatment will be added after the report of the several cases. (See page 102.)

"We have already intimated that singular combinations of circumstances repeat themselves, often, in every battle. This, however, can scarcely be considered a singular one. A ball cannot well fracture the femur, for instance, in certain portions of its diaphysis without endangering the femoral artery. How often do we see our hopes of a promis-

\* See Confederate States' Medical and Surgical Journal. Also Richmond Medical Journal, Therapeutic effects of the Ligation of Arteries, by D. F. Wright, of Clarksville, April, 1866.

† By Dr. D. L. Duvall, of Franklin Co., Ky.

ing case of fracture of the thigh dashed by the sudden occurrence of either secondary or indeterminate haemorrhage. In such a case, no necessity more to be regretted could arise, than that of being compelled to make the deep incisions and enter into the tedious search among the inflamed and tender soft parts necessary to find and secure the bleeding vessel at the seat of injury; converting our *comparatively* simple case into one of additional, and most serious, complications—all pertaining to the immediate seat of the fracture. Here we remember that, *according to rule, and not by accident*, large arteries, when wounded *high up*, are not quite so subject to recurrent haemorrhage as when wounded near the extremity of the vessel; because the collateral communications, though sufficient for the purposes of nutrition, are not in such abundance as to produce haemorrhage by the recurrent circulation. The Hunterian operation, then, may be legitimately performed somewhere below the profunda, and the patient saved the greater evil of being operated on in the tissues about the fracture, or what, in our opinion, would be less objectionable,—amputation."

"*Hunterian Ligation to Prevent Destructive Inflammation.*—After the battle of Seven Pines, May 31st, 1862, many of the wounded in the General Hospital at this place (Richmond, Va.) suffered from the most violent and uncontrollable inflammation. The inflammation from gunshot wounds, for sufficient causes, viz., the shock or jar to all the tissues, especially the nerves and blood-vessels of the part, is apt to be more intense than in other wounds of the same parts. Wounds of both the upper and lower extremities resisted all ordinary measures of treatment. Suppuration, in many, had ceased, and, in its place, a bloody water was discharged from the openings and abrasions. The swelling in these cases was immense."

"Six of the above cases\* under our observation were the subjects of arterial lesion. The arteries wounded in the lower extremity of three of these cases were, severally; in one, the peroneal close to its origin; in the other two, the anterior tibial, near the middle of the leg. Profuse secondary haemorrhage occurred in all these cases (see table, page 91, cases 30, 32 and 33), respectively, on the fourteenth, twelfth and tenth day. Ligation was determined on. The extreme swelling and inflammation of the limb, extending even above the knee in all, and in one (No. 30) marked by large patches of *incipient gangrene* on the foot, presented great embarrassments to the operation at the seat of lesion. It was not the difficulties, however, which caused Mr. Hunter's operation to be preferred in all of these cases to Mr. Guthrie's, notwithstanding the risk of recurrent haemorrhage. There was a desirable *incidental benefit* hoped to be attained, which was of even deeper interest, if possible, than the arrest of the haemorrhage. The idea pursued, in departing

\*See Reports of 1st, 2d, and 4th Georgia Hospitals, in office of Surgeon-General—Ligation of Arteries.

- from the rule, was no less than *the experimental effort to cure the inflammation in the limb, by cutting off its arterial supply, by ligation of the main trunk which supported the inflammation.* The femoral artery was tied, in each case, near the apex of Scarpa's triangle. The haemorrhage ceased immediately in all three of the cases, the swelling began to decline within twelve hours, and, in three or four days, the limbs were reduced to very nearly their natural size, the discharge having changed from bloody water to healthy pus."

"*Results.* Case 30 (J. M. Orr, of present paper), recovered slowly, on account of the sloughing out of the patches of gangrene, *which had shown themselves previous to the ligation.* These surfaces granulated healthily and cicatrized firmly. The suppuration was profuse and long-continued."

"In case 33 (Drury B. Early, of present paper), the result was most satisfactory and complete; the swelling had disappeared in three days—the appearance of the wound wonderfully improved—the discharge became healthy, and the subsequent progress of the case, rapid and favorable, ending in entire recovery.

"In case 32 (S. A. Willingham, of present paper), it was discovered after the complete subsidence of the swelling, that the fibula was broken. Still the case progressed well. The inflammation was entirely subdued. On the tenth day after the ligation, *recurrent haemorrhage supervened*, causing great infiltration below the knee in the popliteal space, and rupture of the nearly cicatrized gunshot wounds. This patient was greatly exhausted and was not thought to be able to bear the ligation of the peroneal artery. Amputation above the knee was determined on. Only one artery, superficial and of small size, required tying in the stump. It is worthy of remark, that the stump healed *by the first intention*—a most unusual result of a *secondary amputation.* It is not unfair to presume that the previous ligation favored this rapid recovery of the stump."

"In the three cases of arterial lesion in the superior extremity, in which ligation of the main trunk in its continuity was preferred, *in order to subdue inflammation*, the arteries wounded, respectively, were the brachial near the elbow, in one, and the radial in both the others. The inflammation was greatly modified, though not in so marked a manner—except in one of them—as in those of the lower extremities. The patients all recovered; and in two of them recurrent haemorrhage took place, but was controlled without resorting to further ligation. In the exception mentioned, no recurrent haemorrhage occurred, and the inflammation seemed to be completely *strangulated* throughout the hand and forearm by the ligation of the brachial artery."

"It will be observed that, in the above six cases, in which the rule of Mr. Guthrie was departed from, recurrent haemorrhage took place in three of them, but only in one in such degree as to require an opera-

tion. The advantages gained in departing from the established rule would be more apparent from a detail of the cases than in the above very condensed notes. The cases are referred to more in illustration of the circumstances in which departure from the rule may be considered justifiable, than with any view of advocating the Hunterian practice in opposition to the more reliable one of Mr. Guthrie."

"And lastly; though there are, doubtless, many other considerations which may justify the ligation of an artery in its continuity in the treatment of haemorrhage, we will refer but to one more: For instance, suppose a patient in a state of extreme exhaustion, whether from haemorrhage or other causes:—Consecutive haemorrhage in some inaccessible artery, for instance, as the peroneal or posterior tibial high up, occurring in a patient of this kind, especially if complicated with great tumefaction and consequent change in the histology of the parts, would present a case, even for the most practised operator, of unavoidable delay. A prolonged and trying—we had almost said blind—search among clots and fibrinous masses and condensed infiltrated tissues, every one who has tried it knows full well, is sometimes the only route to the open mouth of the bleeding vessel in such cases. This greatly exhausts the strength of the patient, and lessens—indeed destroys—his chance of life. Under such circumstances, the Hunterian operation would be preferable, especially in a wound of the lower extremity. In the first place, it arrests the haemorrhage for the time being, at least, and affords a *chance* of even permanent arrest; and secondly, by cutting off the main stream from the support of the inflammation and general turgescence, the condition of the limb may be so improved that, in case the recurrent haemorrhage should take place, a less embarrassing state of things will attend this more desirable operation. The adoption of the one operation gives a chance for life; we think we have seen the adoption of the other, under just such circumstances, take it away." (Manual Military Surgery, page 106.)

In addition to the above abstract from the text of the chapter referred to, we introduce here the following, found on pages 104-5, as containing pertinent and direct records of our opinion, as well as *facts* relating to the subject:

*Note.*—"As the subject has only a relative bearing on the main object of the present paper (haemorrhage), attention is called, only in a note, to the above practice of ligation to subdue or control inflammatory action. We believe that the cases of Privates C. A. Reid and Drury B. Early (see table, page 91, cases 31 and 33), ligation in one, June 5th, in the other, June 11th, 1862, are the first cases on record in which this measure was adopted with reference to the proposed result. In all of the six cases, the Hunterian operation was chosen with the distinct end in view of combatting and checking, if possible, the destructive progress and, in some, the septic tendency of the inflammation. In all of

these, the pain, the swelling and turgescence were almost immediately relieved, and the most remarkable change was soon presented, as seen in the character of the discharges."

" Surgeon A. C. Thom, of the Confederate States Army, has kindly furnished us notes of a case in which he subsequently adopted the Hunterian ligation of the femoral, and in which the beneficial results were exhibited in the most marked degree—'the inflammation relieved, as by magic.' "

" The application of the ligature in cases of elephantiasis, and for malignant diseases of the face, does not, it appears to us, interfere with any originality which the principles here practised may possess. The present operations, besides being applied with an entirely different object, fully answered the proposed end, while the others did not. We feel confident that this practice will become one of frequent application in the treatment of otherwise unmanageable inflammation, under a variety of circumstances authorizing its adoption."

In order to complete the abstracts bearing upon our subject, we quote from page 152, of the same chapter : Subject—Ligation of the Inferior Thyroid Artery. Here we must, also, present both text and note :

" Sir Everard Home, Walther, Theden, Langenbeck and others recommended the ligation of these vessels, together with the superior thyroids, branches of the external carotid, for the cure of bronchocele ; the operation has been long since abandoned for this purpose, on account of its difficulties, and still more on account of the unsuccess attending the practice."

*Note.*—" In these cases, the cause of failure is, that the abundant anastomosis of the supplying arteries soon re-established the excess of nutrition, and the tumor continued to grow, because its *feeder* could not be *permanently* cut off. Indeed, so long as a part exists, we cannot *permanently* diminish its blood-supply, and hence, whenever the cure depends upon that, it fails. The collateral circulation, in time, certainly enlarges, so as to be adequate to even the *morbid* appetite of the hypertrophic parts. The measure of ligation, as applied to *inflammation*, is different ; here, the morbid demand for blood is evanescent, existing only so long as the causes of irritation at the wound remain. If its *feeder*, the main trunk, is cut off, the diminution in the supply, though not permanent, is not *required* to be so, still it is sufficiently so to allow of the recovery of the parts before the collateral circulation can be fully established. If inflammation was of a nature to demand for its cure the permanent diminution of the blood-supply, then ligation of the main trunk would be of no avail. It is most fortunate, in the general interests of humanity, that we cannot cure tumors and other morbid conditions dependent upon excessive nutrition, by cutting off their arterial supply. The possession of that power would involve a denial to us of one far more important, viz., that of ligating to cure aneurism

and to arrest haemorrhage—for, in that case, wherever the main trunk of a limb was ligated, for any object whatever, its nutrition would be permanently destroyed, and the organ it supplied would consequently perish."

The cases referred to in the above extracts, will be found more fully represented in the following report, made up partly from memory, but assisted, in all essential particulars, by accurate records made at the time the treatment was applied :

#### I. LIGATIONS OF THE FEMORAL ARTERY.

CASE 1.—C. A. Reid, aged 17 years, a private in one of the Alabama regiments, received a gunshot wound with a minnie ball, at the battle of Seven Pines, May 31st, 1862. He was brought to Richmond and placed in the Second Georgia Hospital, then in immediate charge of Surgeon D. C. O'Keeffe. On examination, the ball was found to have passed obliquely through the fleshy part of the thigh, near its lower third, traversing the region of Hunter's Canal, in such a manner, as that, in passing out of the lower and outer part of the popliteal region, the outer margin of the calf of the leg was deeply grooved. On examination of the case, the femoral artery was, of course, recognized to be in great danger, notwithstanding, as yet, the absence of both haemorrhage and diffused aneurism. He was placed in a comfortable position, and closely watched while cold-water dressings were applied to the wounds.

June 2d—Third day after the receipt of the wound. To-day obscure pulsations are perceived in the region below the wound, and, on careful examination, a considerable tumor is observable in the deeper parts involved in the track of the ball. The limb, even thus early, had become very painful, and was much swollen.

On the 3d and 4th, the size of the aneurism was gradually enlarged, the pulsations becoming more and, more decided, and, of course, extending with the breadth of the tumour. The general tumefaction was greatly increased, and he complained of pain along the course of the nerves of the leg, for which reason he was unable to sleep. There was no purulent discharge from either of the wounds in the thigh, or from the one in the leg, but a scanty discharge of bloody serum.

June 5th.—To-day the tumour is greatly enlarged; pulsations very strong and widely extended; danger of rupture of pseudo-sac of aneurism apparently imminent. The general condition of the limb unpromising; the two wounds upon the thigh, and the superficial wound upon the leg, have an unhealthy appearance; their edges are swollen and everted; the sanguous discharge abundant; pulse at wrist, good; the patient cheerful and willing for any operation.

Having determined upon ligation, the day previously, and regarding the Hunterian operation sufficiently safe, as the sac was as yet unbroken, we made the necessary incisions in the lower part of Scarpa's triangle

and secured the femoral artery, at about twelve o'clock, M., about one inch above the upper edge of the tumour. The ligature used was white saddlers' silk of ordinary size, doubled, for security against breaking, and to avoid cutting through the coats of the artery. The wound was closed with adhesive strips, with a light compress and loose bandage.

The pulsation in the tumour ceased from the moment of the tightening of the ligature. These did not return, at any time, in any perceptible degree, during the progress of the case. On the completion of the dressing, the patient expressed himself as greatly relieved of the pain in the limb, and also of the unpleasant tension in the tumour. He slept well during the night, having no return of pain.

On the first morning after the operation, a marked diminution in the general size of the limb was observable ; there was much less heat, but the temperature was not sensibly below that of the other limb. The skin over the tumour was quite loose, and the general cutaneous and subcutaneous envelope pale and much shrunken, and more moveable upon the muscles than before the operation.

June 8th.—The patient doing well in every particular.—There has been a most remarkable diminution in the size of the limb operated on, from the rapid absorption of the effused serum in the general subcutaneous cellular tissue. The wounds of entrance and exit in the thigh, and the slighter wound in the leg, have undergone a marked change in their appearance ; the large flabby elevations around these openings have shrunken into small, red, healthy granulations, covered by a thick cream-like pus, and there is no longer any more of the thin sanguous water exuding from these surfaces. The clots composing the sac do not appear to become diffused, and it is not thought advisable to open the tumour, or even to probe it, in the present "well-doing" condition of the limb.

On the 15th, the tumour had gradually diminished, the wound of incision had healed kindly, the ligature as yet remaining. The gunshot wounds were healing rapidly, discharging a small amount of healthy pus, sometimes mixed with diffused blood. The general condition of the limb, as to temperature and circulation, were very satisfactory throughout the case ; the pulsations in the dorsalis pedis artery feeble, but plainly perceptible. Swelling of the limb had entirely subsided.

The case continued to progress favorably, in every particular, and the patient left the hospital, on furlough, for his home in Alabama, six weeks after the operation.

Having carefully observed in this, our first case, the remarkable effects of the Hunterian ligation upon the tissues supplied by the femoral, as shown by the rapid subsidence of the swelling, the disappearance of turgescence, the improved condition of the wounds, and the change in the discharges from sanguous to healthy pus, we could not fail to attribute these important results mainly to the diminution in the force and fulness of the circulation caused by the ligation of the main trunk supplying the

capillaries of these engorged structures. The idea that such ligation, in all similar cases of threatening and destructive inflammation, especially where haemorrhage gave the occasion, soon, therefore, became familiar, and, on repeated reflection, the practice became, to our mind, most rational and expedient; hence we determined, at the earliest possible period, to give the measure a fair trial in some of the sad cases that were then every day presenting themselves in the hospitals under our direction. Fortunately, many days did not elapse before a most legitimate opportunity for further experiment presented itself in the case of another soldier in the adjoining bed, wounded in the same battle.

CASE II. Drury B. Early, a private in a Georgia Regiment, aged 18 years, received a gunshot wound in the leg, on the second day, June 1st, of the battle of Seven Pines, and was admitted to the second Georgia Hospital. The ball had entered the lower portion of the calf, ranging somewhat upwards and towards the anterior aspect of the leg towards a point between the tibia and fibula, but not passing out. The direction of the track was such that either one or both of the tibial arteries might have been severed. There being no haemorrhage, and search having been previously made for the ball, which failed, no further operative measure was taken. The case was treated with cold-water dressings, to subdue the inflammation. The treatment did not appear, however, in the least, to arrest its rapid progress.

Our attention was not particularly called to the case until the tenth day after the receipt of the wound, at which time secondary haemorrhage took place. The haemorrhage was not very profuse, and the Assistant Surgeon in charge of the case kept it in check at first by a compress and bandage. The condition of the limb however, and a *certainty* of a return of the haemorrhage determined us on an early operation.

Having been requested by the Surgeon in charge to operate, on the next day we invited to be present Surgeon Gen'l S. P. Moore, Surgeons C. H. Smith, A. N. Talley, A. E. Peticolas and James Dunn, with each of whom we had repeatedly conversed respecting our views of the effect of arterial ligation upon the progress of inflammation. The appearance of the limb was so unpromising that our interview partook somewhat of the character of a consultation. The measure of amputation above the knee, in preference to the proposed ligation, being debated, one of the Surgeons present consented good-naturedly to the ligation, intimating that "both sides would be accommodated in this case, as amputation would ultimately be found necessary."

At the time of the operation there was great tumefaction, extending fully up to the knee, the skin was mottled from congestion; it was stretched tightly over the other tissues, and, in places, had a shining appearance. There had appeared, upon the outer and anterior aspect of the leg, a dark elevation into which the Assistant Surgeon had made an incision, as a counter opening, hoping to find the retained ball.

From this opening the haemorrhage had emerged. From the posterior wound, and from certain superficial abrasions, was there issuing a thin, sanguous discharge, which had taken the place of the pus *when suppuration ceased three or four days previously*. The general condition of the patient could not be considered very bad ; the haemorrhage had not been excessive, and his depression appeared to be the result of the loss of sleep and of extreme suffering, from extensive local inflammation, rather than from general and more permanent exhaustion of the vital powers.

The femoral artery was ligated in the lower part of Scarpa's space. The wound was closed with adhesive strips, and a light compress and bandage applied. The limb was placed in a comfortable position, and the cold-water dressings ordered to be discontinued.

June 12th. The patient slept well during the night, and is free from pain ; general appearance of the leg greatly improved ; color of skin more natural ; temperature somewhat above that of the sound limb ; lips of wounds less tumefied than on the day previous. The general swelling of the limb is so greatly reduced to-day, that the ball, which, until now, had not been found, is readily discovered by its prominence under the skin, upon the anterior and outer aspect of the leg where it had been lodged, and is now removed by a slight incision. The discharge is still sanguous. No examination made of wound of operation.

June 14th. Patient doing well in every particular. The general tumefaction of the limb entirely gone, the skin being now wrinkled and loose, from its recent over distension. In place of the bloody water, *the wounds of the leg are all discharging a moderate amount of healthy pus*. The granulations have contracted in size ; they are red, florid, and healthy.

A full report of Early's case would not be tedious, for it was one of short duration, ending in recovery ; but it is unnecessary to encumber our paper with trivial details, all tending in one direction. His wounds soon ceased to suppurate, and cicatrized firmly ; he had no recurrent haemorrhage, nor any other untoward symptom. We cannot here state the exact time of our last visit to him, as the books have been destroyed, but he was well and ready to go home on furlough, and had to wait many days for Reid, whose ligation was six days previous to his. Indeed, we do not remember to have treated any case, during the war, the results of which more promptly and abundantly fulfilled our expectations in every particular, than this one of Drury B. Early.

CASE III.—Private S. A. Willingham, of — Georgia Regiment, received a gunshot wound in the leg, in "The Seven Days' Battle around Richmond," June 26th, 1862. He was brought the day after to the first Georgia Hospital, then in charge of Surgeon J. A. S. Milligan. We did not see him until the eighth of July, the twelfth day after the receipt of the wound, at which time a profuse secondary haemorrhage occurred. We were now called in consultation, and requested to operate.

The patient was much exhausted by the sudden loss of a considerable amount of blood. The limb was very much inflamed, and swollen to nearly twice its normal dimensions. The inflammation and swelling extended above the knee. The ball had, apparently, entered behind, considerably above the junction of the middle and upper third of the calf at the inner side, and ranged forwards and outwards, passing out in front of, and somewhat below, the head of the fibula. There was no purulent discharge from either wound. *Suppuration had ceased several days previously.*

A track thus situated, in the enormously swollen condition of the parts, left it questionable which might be the particular artery wounded; whether the posterior tibial, the peroneal, or the popliteal. Guthrie's operation, it is true, might have been performed successfully, so far as the haemorrhage was concerned; but it was decided, in consultation, that, in addition to the difficulties of the operation, under the circumstances, such a procedure, involving parts so near the knee-joint, already advanced almost towards a putrefactive condition, would compromise all chances for the patient's limb, and, perhaps, for his life. We say here "for his life," because it is well known to the Confederate Surgeons, about Richmond, that but a lamentably few of our soldiers recovered after an amputation above the knee, in what is known as the secondary period—they nearly all died.

Under these circumstances, and with the very encouraging cases of Reid and Early still under our observation, we decided upon the Hunterian operation.

The patient, after a stimulating potation of brandy, was put under the full influence of chloroform, and the ligation was made by an incision some distance above the apex of Scarpa's triangle. The haemorrhage ceased at once. The limb was placed in a comfortable posture, upon pillows, the foot somewhat elevated, and the Assistant Surgeon advised to order a decided dose of laudanum, after the patient had fully recovered from the chloroform. We did not advise artificial warmth, or even flannel wrappings in this case, nor, indeed, in either of the preceding cases, as, according to our theory, upon which the measure of ligation, *under the present circumstances*, is founded, such precautions are not necessary.

A marked improvement in the condition of the limb was observed on the morning after the operation. The skin was much less congested, the surface more natural in temperature, and the tumefaction greatly reduced. Suppuration from the wounds was fully re-established on the third day, and the limb rapidly resumed its natural size and appearance, with the exception of the wrinkling of the skin over the leg and foot, resulting from the sudden subsidence of the swelling. At this time, on particular examination of the parts about the wound, a discovery, impossible before, on account of the great tumefaction, was made, that the fibula was fractured a short distance below the neck of the bone,

For brevity, we shall complete the history of this case of Willingham in the words of our former published report:—"Still the case progressed well. The inflammation was entirely subdued. On the tenth day after the ligation *recurrent haemorrhage supervened*, causing great infiltration below the knee and in the popliteal space, and rupture of the nearly cicatrized gunshot wounds. The patient was greatly exhausted and was not thought to be able to bear the ligation of the peroneal artery. Amputation above the knee was determined on. Only one artery, superficial and of small size, required tying in the stump. It is worthy of remark, that the stump healed *by the first intention*—a most unusual result of a *secondary* amputation. It is not unfair to presume that the previous ligation favored the rapid recovery of the stump."

It will here be seen how briefly we were forced to interpret the eloquent facts of this most significant and instructive case. The simple statement that "the previous ligation favored the rapid recovery of the stump," was all that, with propriety, we could introduce on the pages of a work, the intent and purpose of which was, to serve as a terse and portable manual for medical officers in the field. The mention of these cases was barely admissible—a lengthy *discussion* of them, impossible. Simply to record the prolific data, and to preserve, somewhere, the essentials of a practice we considered valuable, as well for the future, as for that distressing present, was all that those momentous times could be asked to tolerate.

Willingham's case, taken in connection with the others, requires, now, no special comment. To our mind, the fact is *unquestionable* that the rapid healing of the stump was due, and alone due, to the favorable condition of the tissues of the flap brought about by the previous ligation of the femoral artery. The value of this fact of healing by the first intention can scarcely be appreciated except by those who were familiar with the hospital experience of this particular period of the war. At that time, to amputate a lower extremity above the knee, during the secondary period, that is, after inflammation had been established, was not only to entail upon the patient a protracted, tedious, and exhausting time of drainage and suffering, but, in the vast majority of cases, to sign his death-warrant. As we have said before, *they nearly all died*. Such a thing as healing by the first intention after a secondary amputation was unheard of, not only at that time, but at any time, before or after, during the continuance of the war.

A dissection of the amputated leg showed that the peroneal artery had been severed within a quarter of an inch of its branching off from the posterior tibial, leaving no room for the application of a ligature, had we chosen Mr. Guthrie's method of ligation.

While yet engaged in this operation of amputation, we were solicited,

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\*See Manual of Military Surgery prepared for the use of the Confederate Army. Chap III. On the arteries, page 194.

with great earnestness, to visit another case of a gunshot wound of the leg, in the case of a soldier, at a private house, on Church Hill, who was described as a case of secondary haemorrhage. In one or two particulars, this case is more remarkable than any of those already recounted.

**CASE IV.**—Joseph M. Orr, aged 18 years, a private in one of the early Georgia Regiments, was wounded with a Minnie ball in the “Seven Days’ Battle around Richmond,” June 27th, 1862. He was carried to one of the hospitals at that post, but was transferred, by permission, to the private quarters where he was treated. Secondary haemorrhage occurred on the morning of the fourteenth day after the receipt of the wound. He was under the care of a practitioner of the city, and we did not see him till nine o’clock, P. M., of the day of the bleeding.

We found the patient in a feeble condition, from haemorrhage, from loss of sleep, and from irritative fever. The ball had entered on the front aspect of the leg, about the junction of the upper and middle third, and on the line of the anterior tibial artery; the wound of entrance was, therefore, between the tibia and fibula. There was a wound of exit posteriorly, corresponding with the general direction of the track. The haemorrhage had issued from the anterior opening, but the bleeding had ceased spontaneously, as it had done several times during the day, before we arrived. From the clots in the wound, the direction of the track, and all the circumstances of the case, we were confident that the anterior tibial artery was the subject of lesion. We determined on ligation, and, as the bleeding had been controlled, appointed an early hour, next morning, to meet the attending physician.

We find it difficult to give any adequate idea of the general condition of the wounded limb, as it presented itself on the morning of the operation. The patient was a youth of extremely delicate “build;” he was very tall, near six feet, but slim, and without a particle of fat, and but little flesh anywhere. His lower extremities were very long, and the sound limb little more than skin and bone. The wounded limb was enormously swollen; the skin, in places, was purple with congestion, shining from the extreme tension, and stretched to the utmost limit of its capacity. The temperature of the foot was below that of the opposite limb, and the nails were bluish from arrested circulation. Indeed, the turgescence had passed beyond the point of active circulation, and a general stasis seemed to pervade the entire limb, progressively increasing as our examination approached the foot. This stasis, more the result of the overwhelming congestion than from paralyzed innervation of the capillaries, was evidently the initial stage of the termination by mortification. This was proved by the fact that *there was an extensive blister, filled with bloody serum, covering nearly the whole dorsum of the foot*, and another, of a similar character, above the heel, in the region of the tendo-Achillis. The swelling extended fully up to the knee, which was also somewhat

tumefied. The anterior wound was occluded by the clots, but the posterior opening was discharging a large quantity of *bloody serum*. *Suppuration had ceased for several days.*

Even with the convincing experience in the benefit,—with these unmistakable evidences of gangrene before us, we would have been glad to have amputated the leg could we have formed a flap of sound tissues *below the knee*. Amputation above the knee, under the circumstances, was out of the question on account of the universal fatality attending secondary operations in this region at that time. The feature of haemorrhage, we may say, was submerged in the far greater interest, involving the life of the patient, presented in the gangrenous condition of the limb. The preference between Guthrie's and Hunter's operation was not debated. We at once determined on the Hunterian ligation, *distinctly with the view of improving the condition of the tissues to an extent sufficient to authorize amputation below the knee*. This was the most we expected from the operation.

Assisted by Surgeon W. D. Hoyt, we ligated the femoral artery in Scarpa's space in the usual manner at 12 m., (July 12th), of the fifteenth day after the receipt of the injury. The day after the operation—July 13th—we found the patient in a most satisfactory condition. He was entirely free from pain, had slept well, and was in good spirits. The subsidence in the tumefaction of the wounded limb was truly wonderful; the leg had shrunken down to very nearly its normal dimensions, the skin was loose and disposed in folds and wrinkles upon the subjacent tissues. The congestion had disappeared, and the surface was rather paler than natural; the temperature, however, was certainly not much below that of the sound limb. There had been an abundant discharge of sanguous serum from the wounds, as shown by the wide-spread stains upon the bed-clothing, but no return of haemorrhage. We evacuated the large bullæ on the foot by rupturing the cuticle, directing the application of poultices to these surfaces. The patient was ordered a generous diet, with liberal potations of port-wine or brandy-toddy.

On the third day, suppuration became quite abundant. The entire extent of the surfaces occupied by the bullæ, on the dorsum of the foot and above the heel, had assumed the dull-greyish appearance of dead tissue, and it was plain that these patches had been gangrenous before ligation, and were about to separate in two large sloughs. The line of demarkation was already apparent.

July 21st. At this time the limb had been so far reduced in size, that there could not be said to be any difference between it and the sound leg. There was no external evidence of inflammation. The patient was doing well in every respect. The suppuration was far more abundant than could be accounted for by the simple track and the two wounds. A consultation was called by us, and we made a careful examination into the condition of the parts about the wound. An abscess

of large size was found near the lower part of the calf. This collection seemed to result more from the gravitation of the pus, from the general subcutaneous cellular tissue to the most dependent part, than from phlegmonous inflammation; there was no distinct sac, and the cavity communicated freely with the track of the ball. In making a counter opening near this point, we encountered and removed about half of a large Minnie ball. The ball had struck the outer border of the tibia, which was notched, and was probably thus divided, and this portion diverted from its course.

The general cutaneous envelope of the leg seemed sound, but there appeared to have existed *extensive patches of cellulitis* in different parts of the leg. At these places the skin seemed to be undermined by the destruction of the connective tissue, which, it is well known, ever is the first of all the tissues to succumb to septic influences affecting any region of the body. Shreds of this gangrenous cellular tissue were daily separating and being picked away in the dressing of the wounds. It was very evident that the limb had *barely escaped general gangrene*, from the intensity of the inflammation, and that a large portion of the cellular envelope *had yielded*, and was now sloughing away from under the skin after the cause—destructive inflammation—had been overcome by the arterial ligation.

Amputation below the knee was now considered practicable, and was debated in consultation, but the operation was deferred for another meeting, as the gangrene on the foot had not extended a hair-breadth since the ligation of the artery, and as the gradual separation of the sloughs was disclosing a healthy granulating surface beneath; and further, we now began to have hopes of saving even the limb, as well as the life of the patient.

Orr continued rapidly to improve. The consultation to determine the fate of his limb never convened; the very profuse suppuration gradually abated to a reasonable amount for such a condition of parts; the extensive sloughs on the foot slowly separated; that upon the dorsum, at first left some of the white tendons of the digital extensions exposed, and when the one came away from behind the ankle, the destruction was so deep, that “daylight was seen through” the interval between the tibia and tendo-Achillis. The bone was nowhere exposed, however, though this posterior slough extended far enough forward to destroy the skin and cellular tissue over the internal malleolus. The vigor of granulation in all these parts was truly remarkable; cuticle rapidly extended from the edges, and in a short time, little islands of new skin were everywhere to be seen over the dorsum of the foot. His general health had so far improved that, at the end of about six weeks, he accompanied his uncle, who had nursed him most faithfully in Richmond, to Clark County, in Georgia. Repeated letters informed us, from time to time, of the favorable progress of his case, and, finally, of his being well and able to walk about.

In addition to the four cases of Hunterian ligation for inflammation in the lower extremity, above carefully detailed, we, as before mentioned, ligated the brachial in three cases of intense inflammation of the fore-arm and hand, with the most satisfactory results, which have already been presented in former paragraphs of the present paper. We kept no private notes of these arm cases, and used those of the attending assistant surgeons in the respective hospitals in making up the condensed statement of the results, to be formed in our published chapter on the arteries.\* These notes are not accessible at present, but we hope, at some future time, to be able to furnish a full detail of the cases again, through the courtesy of these very intelligent and pains-taking gentlemen.

Before leaving this portion of our subject, we will state that, from our observation of the three cases of Hunterian ligation for inflammation of the hand and forearm, we strongly incline to the belief, that, while the measure is not followed by such decided and striking results as in femoral ligations, on account of the more abundant anastomoses and anastomoses in the terminal and collateral circulation, yet, for that reason, they are *safest* and may be more frequently practised with less apprehension of the evils that may result from a deficient blood-supply to the tissues.

Besides our own seven cases, herein discussed, we would call attention to the five valuable cases, two of the upper and three of the lower extremity, reported by our friend, Prof. Daniel F. Wright, in the April Number of the Richmond Medical Journal. These cases demonstrate great benefit from the practice, not only in inflammation, but also in those more specific and less understood conditions attending hospital gangrene. We cannot regard any of our cases as belonging strictly to this class. Orr's was, undoubtedly, a marked case of *gangrene*, but, in our view, of a nature differing from what is known to us as *hospital* gangrene, the mortification, in his case, resulting from the overwhelming congestion, amounting to complete arrest of the circulation in certain portions of the limb, and thus these portions were as effectually *killed* as though every capillary, throughout their entire structure, had been strangulated by ligatures. Here, verily, "extremes do meet" in one common fatal result: the animal tissues die when the capillaries carry *too little blood*, because the nutrient material does not reach their intimate structure; and they die just as certainly and as effectually whenever the capillaries are *overwhelmed with blood*, because blood-movement and blood-change, so necessary to all the processes of life, are mechanically nullified and abolished.

Inflammation is a condition of the living tissues which, it must be acknowledged, is far better described than defined. The old traditional characteristics: redness, heat, pain and swelling, have been the refuge of pathologists for ages past, and perhaps no better device can now be

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\* See Manual of Military Surgery, p. 104.

resorted to, to convey accurately or exactly the state to be defined. Underlying these four constant elements of inflammation, all acknowledge that there is a hyperæmia or distended condition of the blood-vessels, and so invariable is this turgescence, as a concomitant of inflammation, that it is regarded by all as the proximate cause of the condition—the *ipse morbus*. Our limits will not allow us to enter into a discussion of the subject, but suffice it to say, that whatever may be the *theory* upon this point, nearly all measures of *treatment* appear to recognise the fact that “*too much blood in the part*” is the chief cause of the local distress, and to remove or lessen this redundancy is the chief desideratum of practice. Hence, position, pressure, whether on the artery or by bandage over the entire limb, the application of cold, scarification, and many other measures tending to the same end, of either preventing blood from going into a part, or of removing blood from the part, have been used, from time immemorial, as at least valuable adjunets to whatever other treatment might be applied. This end, we may claim, and have shown, is, at least sometimes, more effectually accomplished *by cutting off the main stream of blood from the engorged region*. The veins are left of their original calibre to drain away the superabundant blood, both the volume and the force of the arterial current are vastly diminished, and the over-distended capillaries soon recover their normal calibre and resume their normal action. Redness, heat, pain, and swelling disappear; and the unhealthy sanguous effusion is replaced by healthy suppuration.

We are fully aware that one of the great dangers of all serious arterial lesions is, that the necessity of ligation in the case of a large trunk endangers by mortification, sometimes the whole, and very often a considerable portion, of the region it may supply, on account of the failure in the collateral circulation. Hence the difference in the results of ligations for traumatic haemorrhage and those for the cure of aneurism; in the one case, the complete obstruction of the large channel of a main artery is necessarily accomplished suddenly, and the collateral circulation cannot be established in time to meet the organic demands of the region it had supplied; whereas, in the case of the aneurism, the long sustained and gradually increasing interruption of the main trunk has afforded time for, and brought about, the dilatation of the collateral vessels, and the final completion of the obstruction by the ligature produces, at last, often little or no disturbance in the nutrition of the tissues. In our cases of inflammation, the general turgescence which had continued, perhaps in most of them for many days, seems to have established, in the multitudinous capillaries and small vessels, a sufficiently ample collateral circulation to answer all the demands of nutrition after the ligation of the main artery. Hence we find that, in not a single one of our cases, does there occur any thing even approaching to gangrene as the effect of insufficient blood-supply; while in every one of them the processes of

nutrition are vastly improved, and the tissues brought safely out of a state of apparently impending mortification.

It must be observed, and this we wish distinctly understood, that we do not recommend, nor have we, in any case, practised the ligation of a main vessel to prevent sound tissues from becoming inflamed. Our precept and our practice pertained to tissues already in a state of very high inflammation, and had for their object the preventing of that inflammation from progressing to the extent of becoming fatal to the tissues by the overwhelming turgescence of the capillaries. There is a vast difference in the two measures;—the one, long and universal experience has shown, as in ligations for traumatic haemorrhage, would be highly dangerous, resulting often in mortification; the other, as shown by Dr Wright's five cases, Dr. Thom's one case, and our own seven cases, has been entirely free from any thing even approaching such a result.

We would not recommend the uniform ligation of arteries for inflammation, even though they be of a very grave character. The operation is indeed a serious one—and it should never lightly be determined on; but under the circumstances, and within the limits faithfully attempted to be defined in this paper, we regard the measure, not only a legitimate one, but one of imperative and bounden duty.

Having encountered, under circumstances the most favorable for study, the facts and experience detailed in this report—an experience which, at the time, we were entirely unaware, as our publication will show, that any one had even approximated before us—we conscientiously believe that, within proper limits, Hunterian ligation must be found a most valuable and available means of reducing the progress of septic inflammation to bounds that are safe and perfectly compatible with the life of the tissues.

And lastly, whether the principle be adjudicated as a new one, or simply as the revival of an old one, long lost and unjustly neglected, we derive, as a practical deduction from our cases, corroborated and confirmed by subsequent cases of others herein mentioned, the ever-safe *Conservative Precept*: That no hand, wrist, fore-arm or elbow; no foot, ankle, leg or knee, should ever be amputated, for excessive or destructive inflammation, especially those cases resulting from traumatic causes—without resorting, whenever the state of the patient will admit of it, to a previous experimental ligation of the artery supplying the affected region.

In extremities already condemned to amputation, if time be allowed, the procedure can certainly do no harm,—on the other hand, it will often save a useful limb, or, at least, contribute to a more rapid healing of the stump.



